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FINAL REPORT

SIMULATED IMAGES FOR IRFPA TRAINING SETS

Volume No. 3

By:

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13. ABSTRACT *(Maximum 200 words)*

This report describes a data base consisting of three scenes, which can be used for training sets to investigate target recognition and aimpoint selection algorithms. Each of the three scenes has been simulated as seen by two sensors; an infrared focal plane array operating in the 8-12 μm region, and an active laser radar operating at 1.06 μm. The data base contains multiple views of each scene, as seen from an incoming missile, corresponding to a 30 Hz frame rate.

Example images are incuded in the report adn the format of the data is described in detail.

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Images for IRFPA Training Sets

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1. Introduction

SPARTA's optical sensor simulation, SENSORSIM, generates signatures of scenes defined by the user as observed by various optical sensor systems. SENSORSIM correctly models illumination from various coherent and incoherent sources, geometry and surface properties of objects in a sensor's field of view, and numerous effects of the receiver optics and detection system for both imaging and non-imaging optical sensors. SENSORSIM uses phenomenological models derived from first principles of physics, rigorous mathematical analysis, and statistically correct distributions of noise to ensure accurate and realistic imagery that are suitable for development of signal and image processing systems.[1]

Under the present effort, SPARTA developed three different scenes containing targets for a missile along with other possible targets, clutter, and background. SPARTA used SENSORSIM to simulate images from two different infrared focal plane array (IRFPA) homing sensors mounted on missiles engaging a target in each of three scenes. Encapsulated PostScript^{TM} files on separate magnetic media accompanying this report contain the images in machine readable format. These text (ASCII) files can be converted to other data formats for use in studies of automatic target recognition.

2. Scenarios of Engagements

The scenario for each engagement consists of the missile's trajectory and speed, the missile's homing sensor, and the scene containing the missile's target, other possible targets, clutter, and background. These elements affect the location of the missile and the visibility of its target in successive frames.

2.1. Scenes

SPARTA used three scenes of different complexity for the IRFPA training set. Scene #1 contains a strategic relocatable target (SRT) in a cluster of trees on a slight crest. Scene #2 contains several buildings surrounded by trees. Scene #3 contains an SRT near two buildings in a cluster of trees. Missiles flying into scene #1 and scene #3 approach the SRT. Missiles flying into scene #2 approach a building located in the center of the scene.

[1] N. R. Guivens, Jr. and P. D. Henshaw, "Image Processor Development with Synthetic Images," in D. J. Svetkoff, Ed., *Optics, Illumination, and Image Sensing for Machine Vision IV*, Proc. SPIE **1416** (1991), pp. 167–180.

2.2. Missile Dynamics

In each engagement, the missile flies along a horizontal trajectory at two kilometers per second and an altitude of 100 meters. Each engagement begins at a horizontal range of seven kilometers from the target.

2.3. Sensors

The IRFPA training set has two missiles, one with an active sensor and one with a passive sensor, that fly against a target in each scene. The active sensor is an incoherent imaging laser radar operating at 1.06 microns. The passive sensor is a thermal imager operating in the band from eight to twelve microns. Both sensors have a standard frame rate of 30 hertz and therefore record one hundred images before terminal maneuver and impact.

Both sensors have a receiver aperture of fifteen centimeters and an angular resolution of one hundred microradians per pixel. This resolution is slightly larger than the diffraction limit for the passive system and about an order of magnitude larger than the diffraction limit for the active system, so diffraction is not a significant effect in either system. Each image in the training set shows a region of the detected image that is 128×128 pixels in size. The individual pixels of corresponding images from the two sensors are registered so that they contain identical portions of the scene.

The images from the active sensor show intensity rather than range because intensity is more consistent with the sensor's frame rate of 30 hertz. These images have a consistent intensity scale, simulating some sort of automatic intensity control mechanism in the sensor system. This intensity control might be achieved by adjusting the energy in each laser pulse in inverse proportion to the square of the range or by some sort of adaptive gain in the receiver.

3. Images on Magnetic Media

SPARTA has provided the images from each engagement as encapsulated PostScript files on a set of fifteen 3.5 inch high density diskettes formatted for IBM and compatible personal computers. Apple MacIntosh computers with the Apples's Superdrive can also read these diskettes.

The name of each image file designates the engagement and sequential order of the image by the following convention:

- The first character of the file name is either `A` for the active sensor or `P` for the passive sensor,
- The second, third, and fourth characters of the file name are `LCH` for scene #1, `BLD` for scene #2, or `BTH` for scene #3,
- The fifth, sixth, and seventh characters of the file name designate the sequential position of the image, numbered `000` through `099`,
- The eighth character of the file name is `D` signifying a detected image from SENSOR-SIM, and
- The file name extension is `.EPS` for encapsulated PostScript files.

Multiplying the sequential position by the frame rate of 30 hertz gives the engagement time of the frame. Thus, the file named `ALCH015D.EPS` is the image obtained at an engagement time of one half second from the engagement in which a missile with the active sensor flies against the target in scene #1. This naming convention provides a distinct file name for each image, so conflicts will not arise if a user transfers all of the images into a common directory of a local hard drive or a network directory.

4. Example Images

The figures on the following pages show representative images from each of the six engagements. Each figure shows frames 000, 030, 060, 090, 095, and 099. The respective engagements times are 0 seconds, 1 second, 2 seconds, 3 seconds, $3\frac{1}{6}$ seconds, and $3\frac{1}{10}$ seconds.

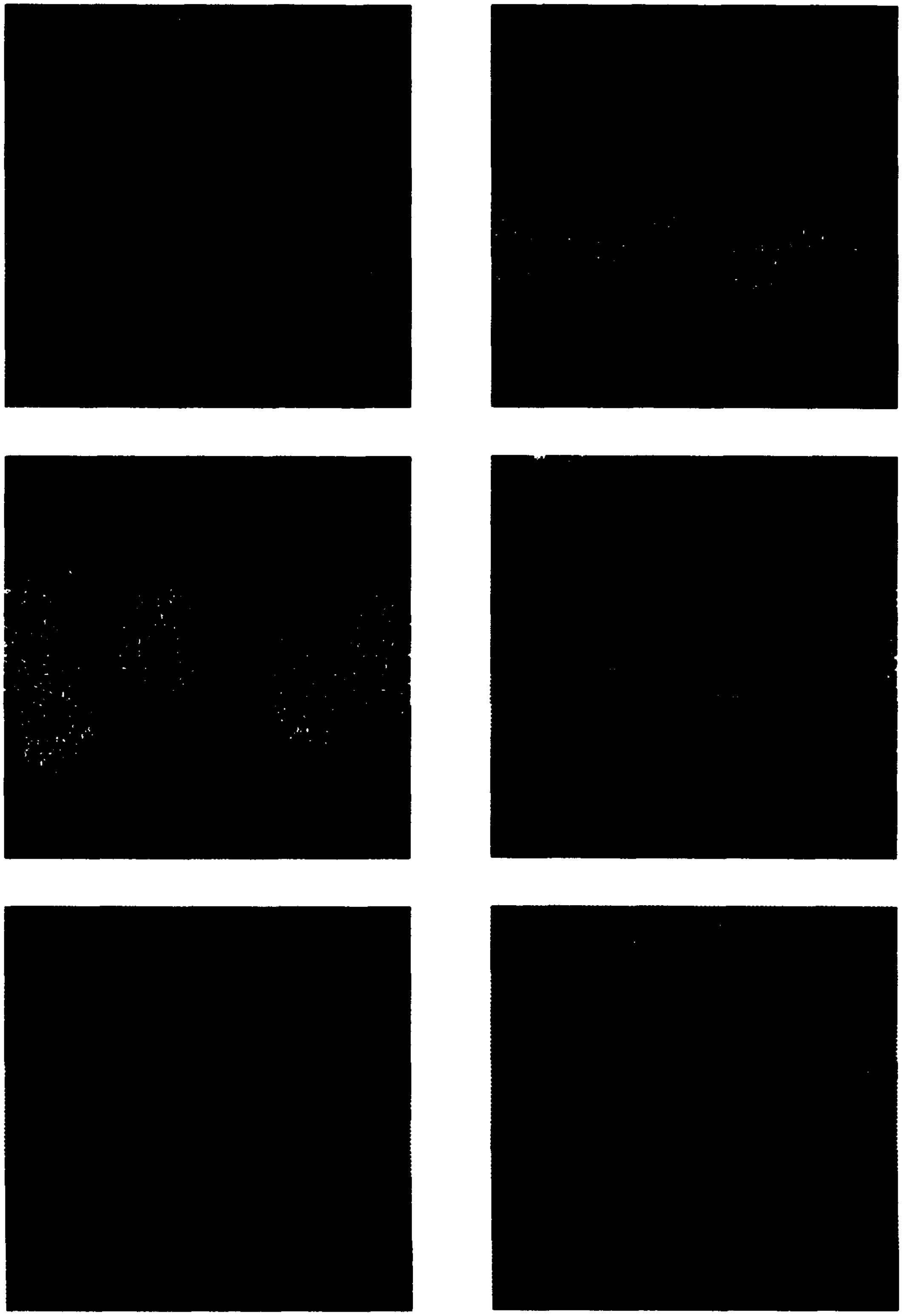

Figure 1. Images of Scene #1 viewed by the active sensor (Series ALCH).

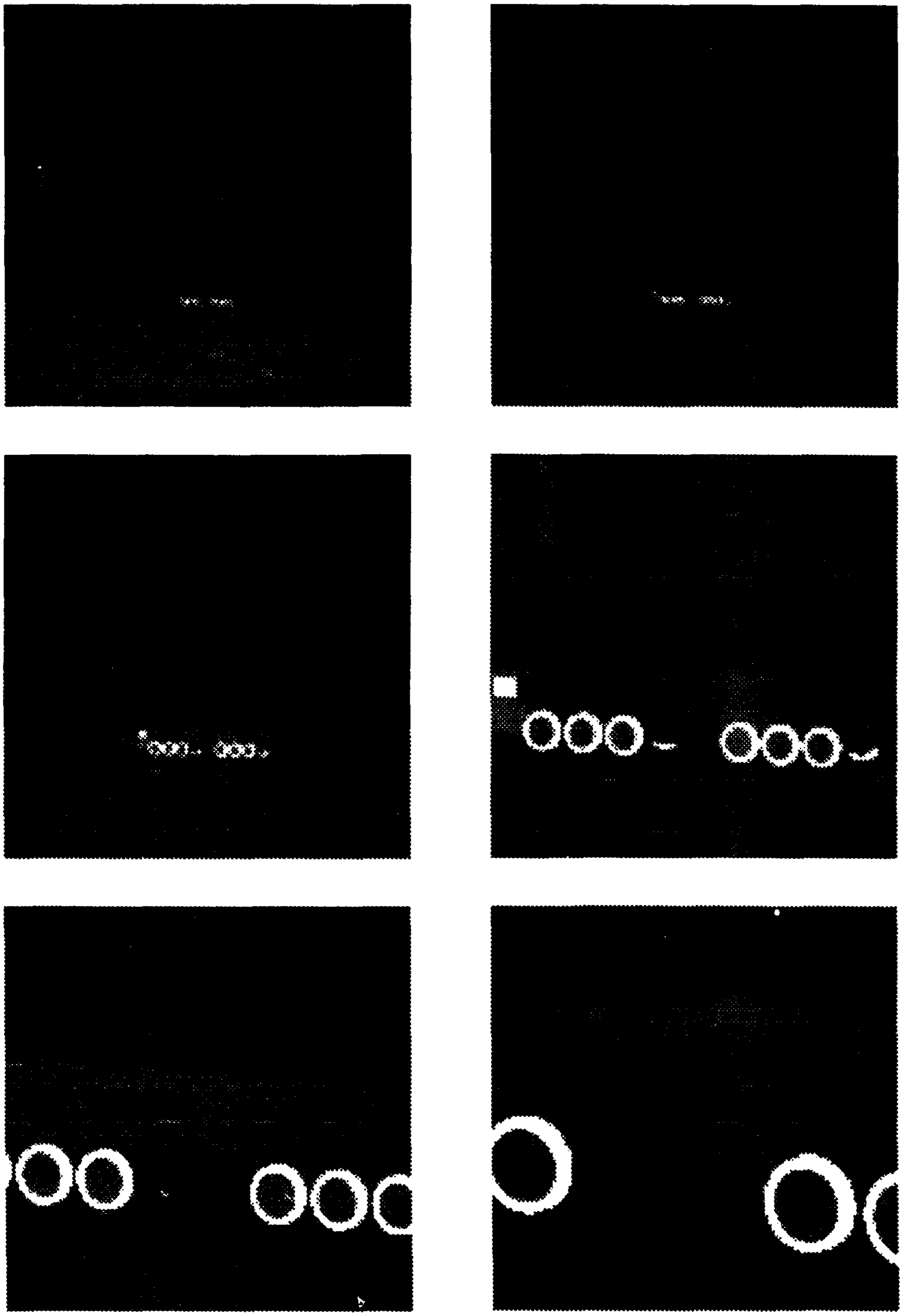

Figure 2. Images of Scene #1 viewed by the passive sensor (Series PLCH).

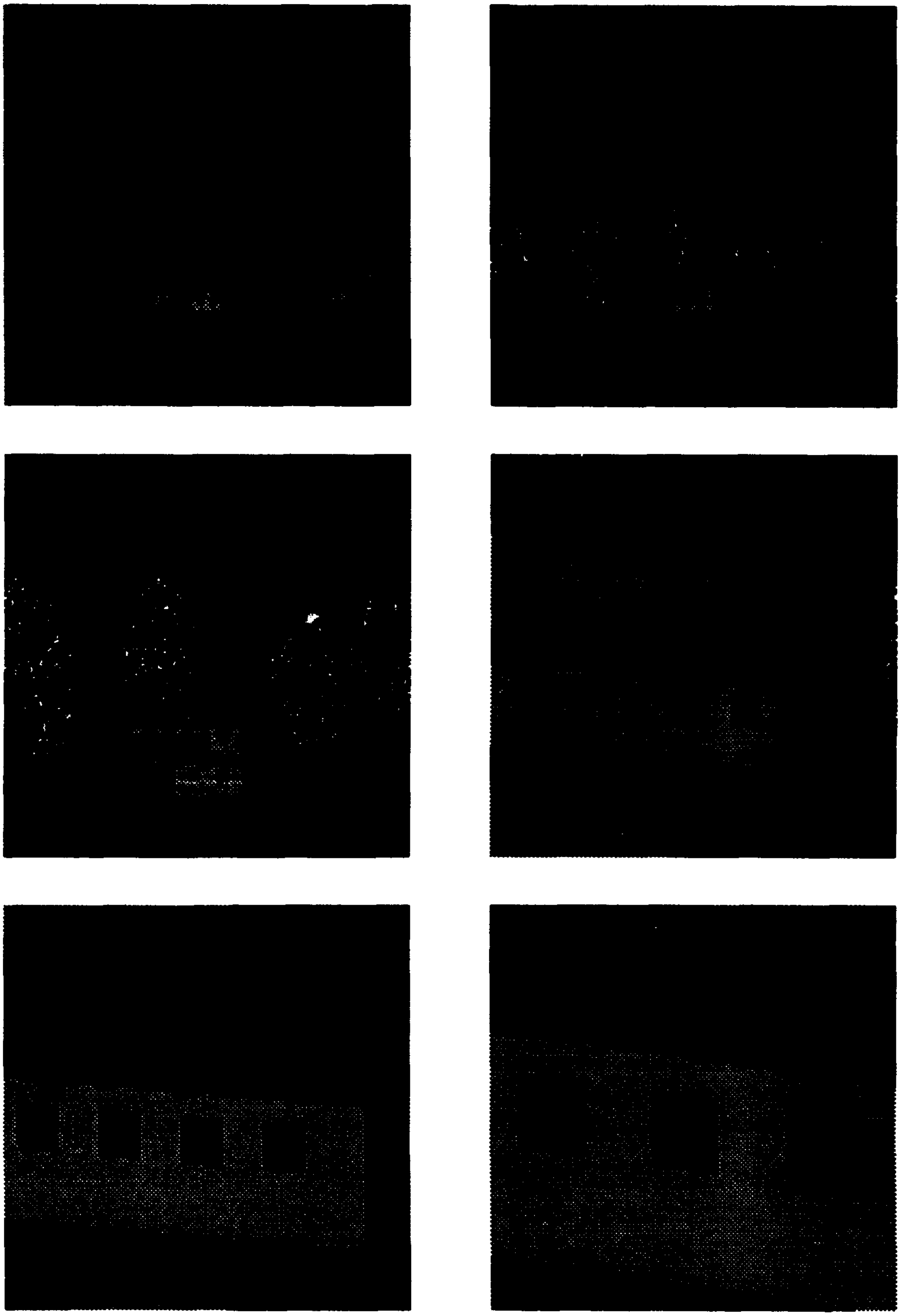

Figure 3. Images of Scene #2 viewed by the active sensor (Series ABLD).

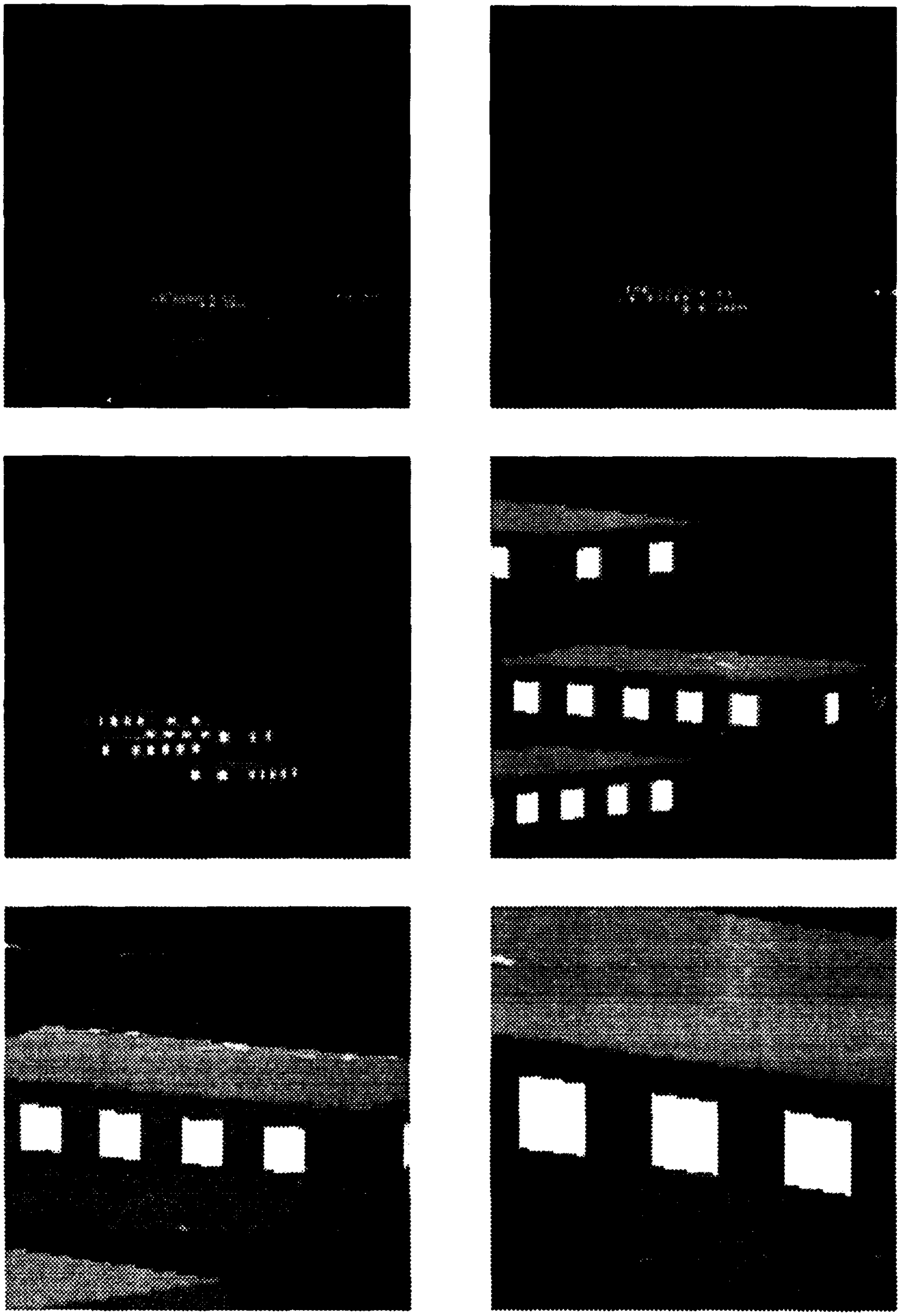

Figure 4. Images of Scene #2 viewed by the passive sensor (Series PBLD).

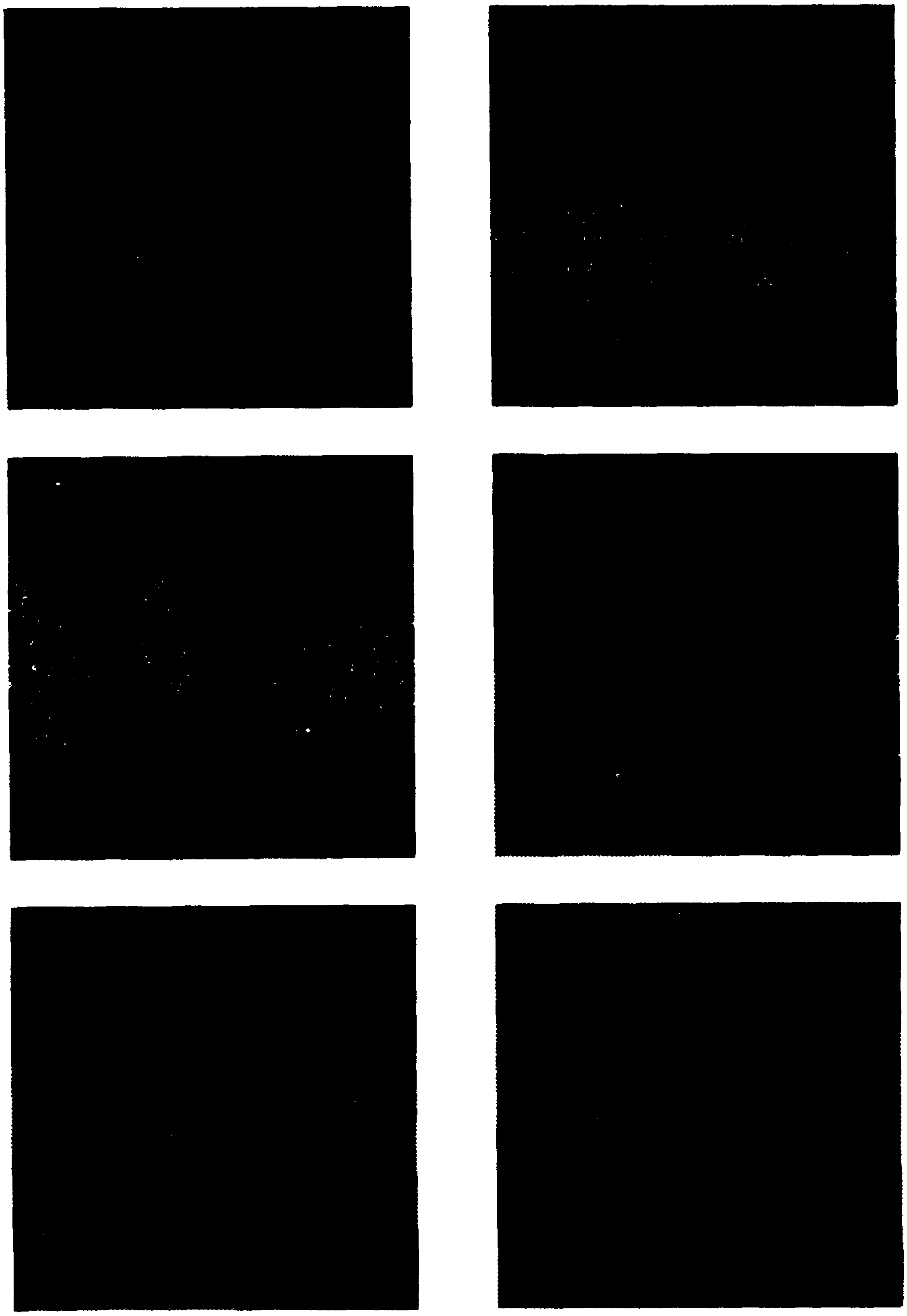

Figure 5. Images of Scene #3 viewed by the active sensor (Series ABTH).

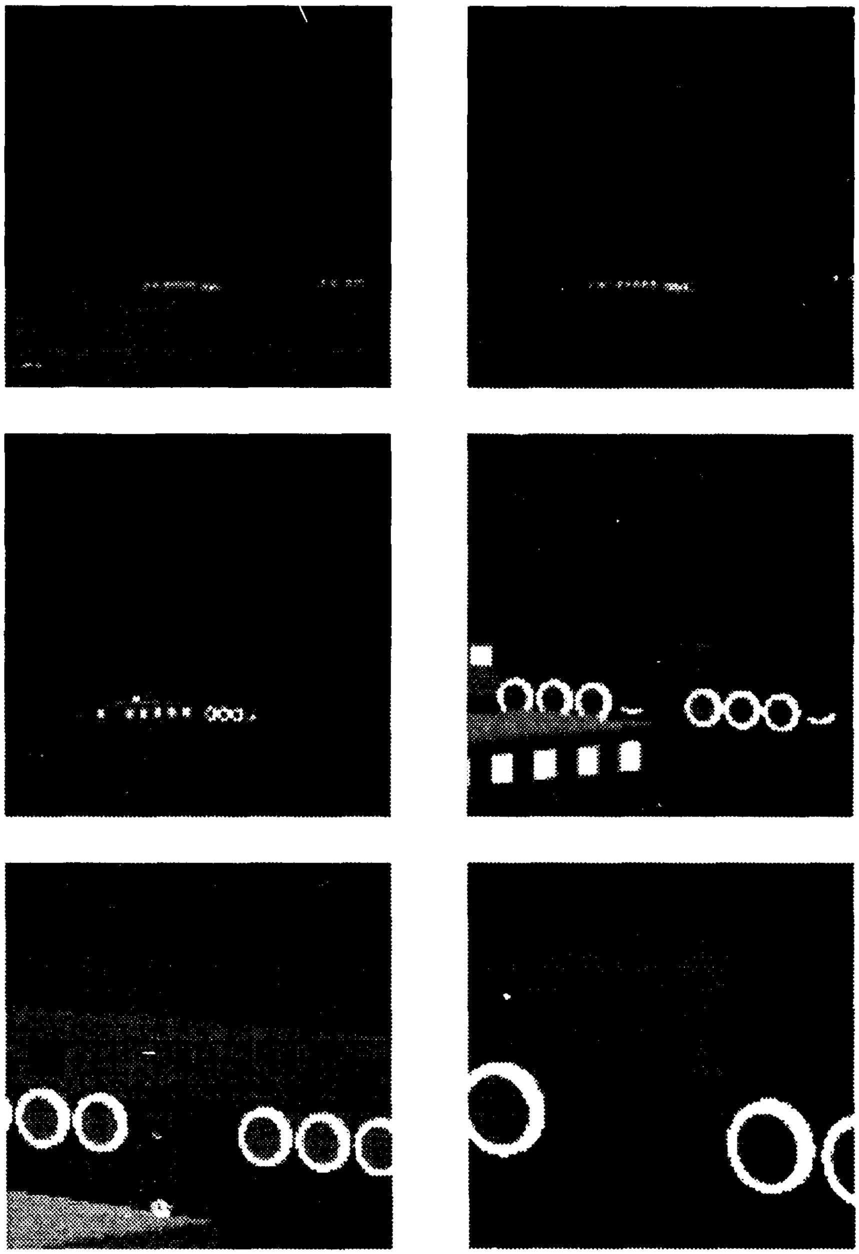

Figure 6. Images of Scene #3 viewed by the passive sensor (Series PBTH).